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(54) **RADIATION DETECTION APPARATUS AND RADIATION IMAGING SYSTEM**

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H01L 27/00 (2006.01)

(52) **U.S. Cl.**
USPC .... **250/361 R**; 250/208.1

(58) **Field of Classification Search**
USPC .... 250/366, 361 R, 338.4; 257/428, 257/E31.129
See application file for complete search history.

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(57) **ABSTRACT**

A radiation detection apparatus comprising semiconductor substrates each having a first surface on which a photoelectric conversion portion is formed and a second surface opposite to the first surface; a scintillator layer, placed over the first surfaces of the semiconductor substrates, for converting radiation into light; and an elastic member, placed between a base and the second surfaces, for supporting the second surfaces of the semiconductor substrates such that the first surfaces of the semiconductor substrates are flush with each other is provided. In measurement of the elastic member as a single body, an amount of stretch of a cubic specimen in a direction parallel to the first surface when being compressed in a direction perpendicular to the first surface is smaller than an amount of stretch of the specimen in the direction perpendicular to the first surface when being compressed in the direction parallel to the first surface.

9 Claims, 5 Drawing Sheets

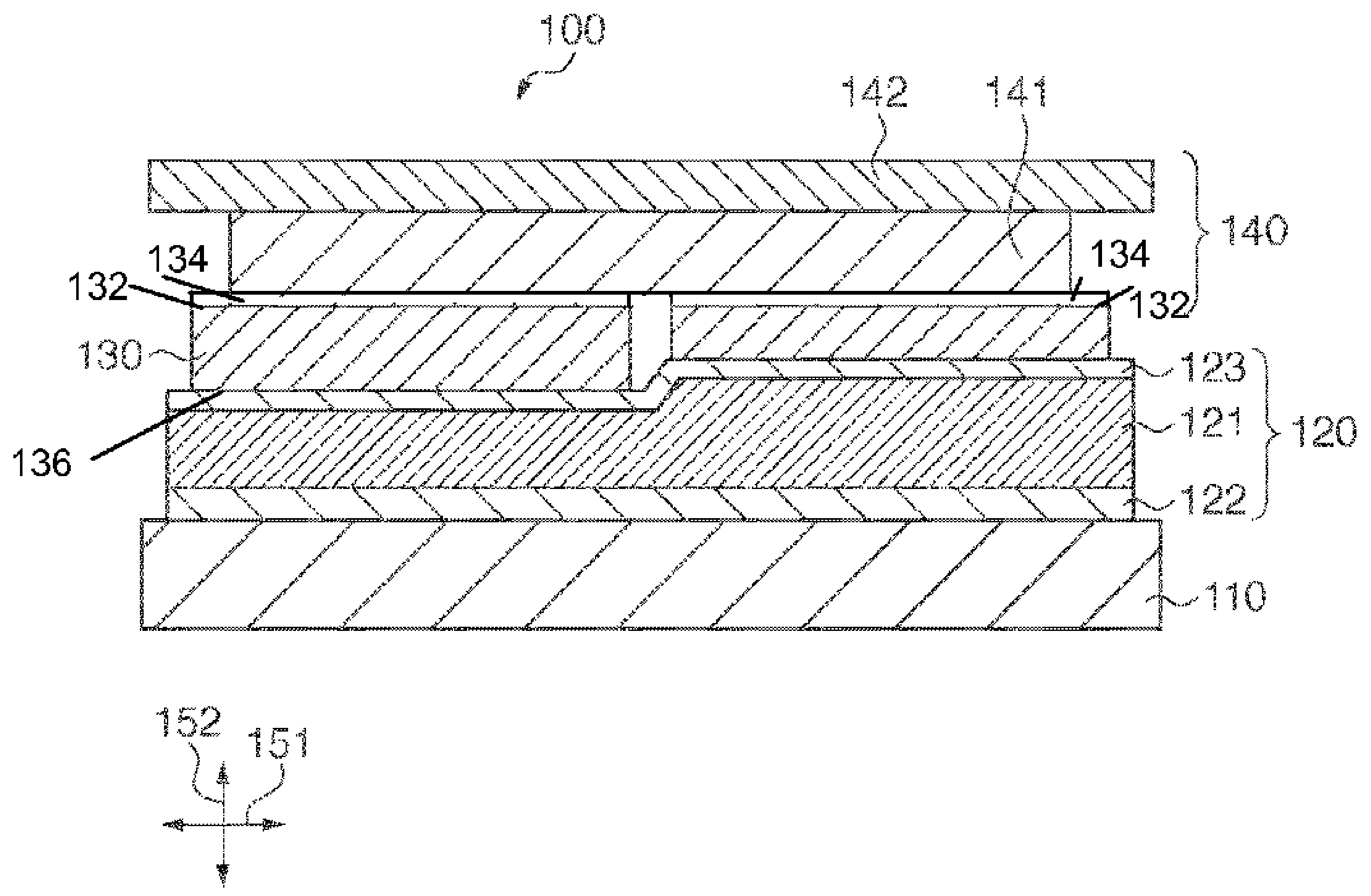

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FIG. 1

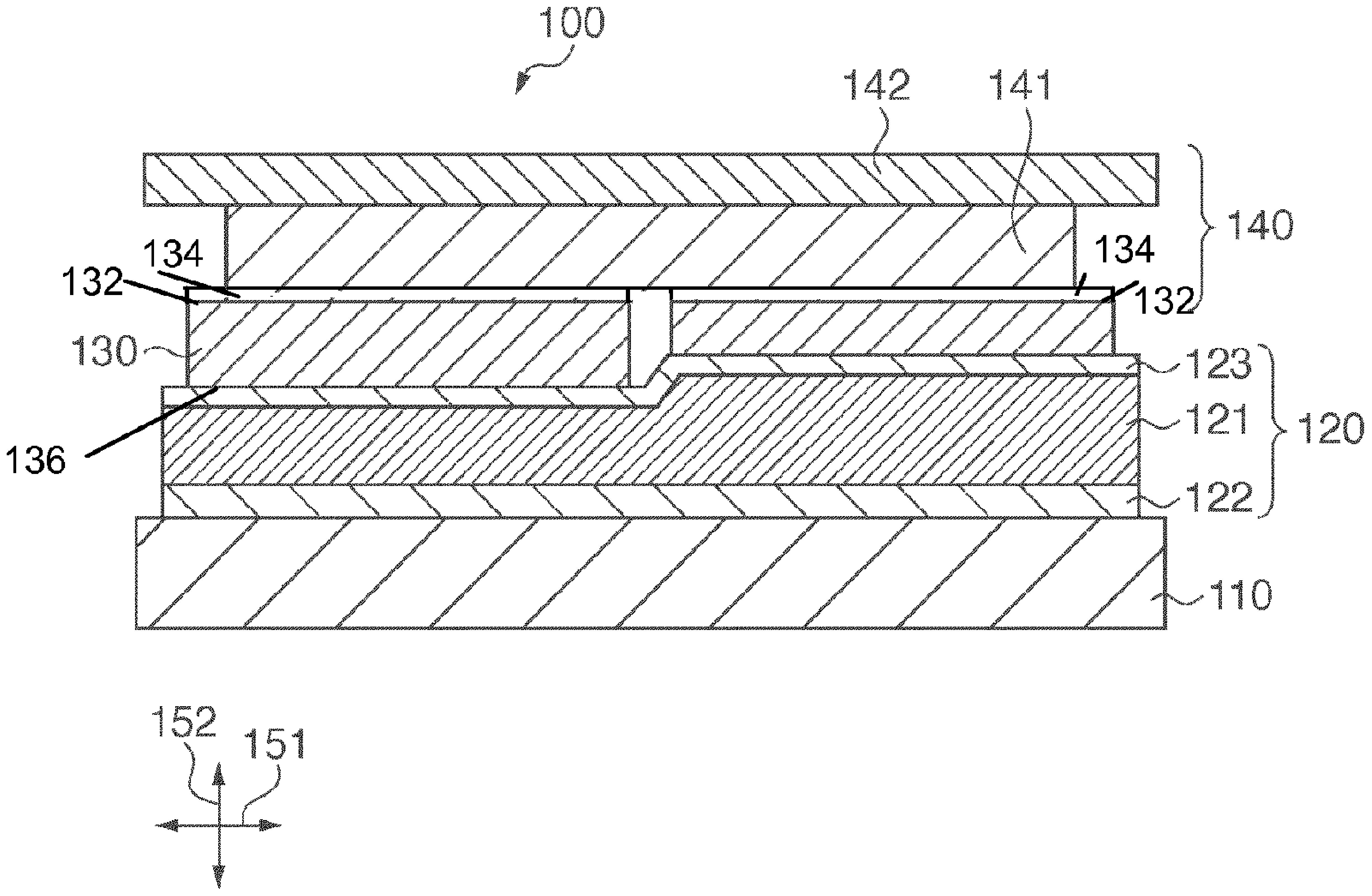

100
142
141
140
134
134
132
132
130
123
121
120
122
136
110
152
151

FIG. 2

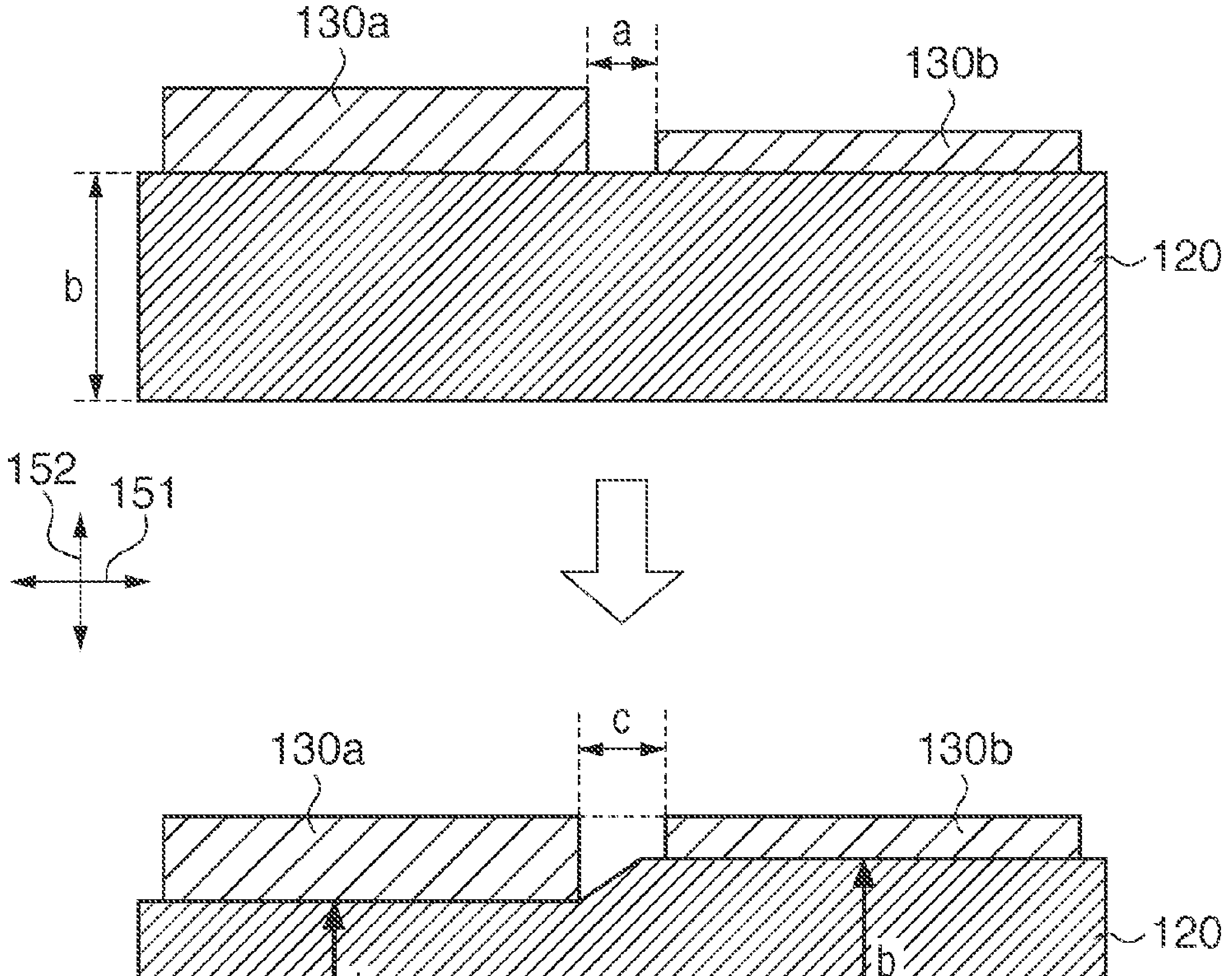


FIG. 3

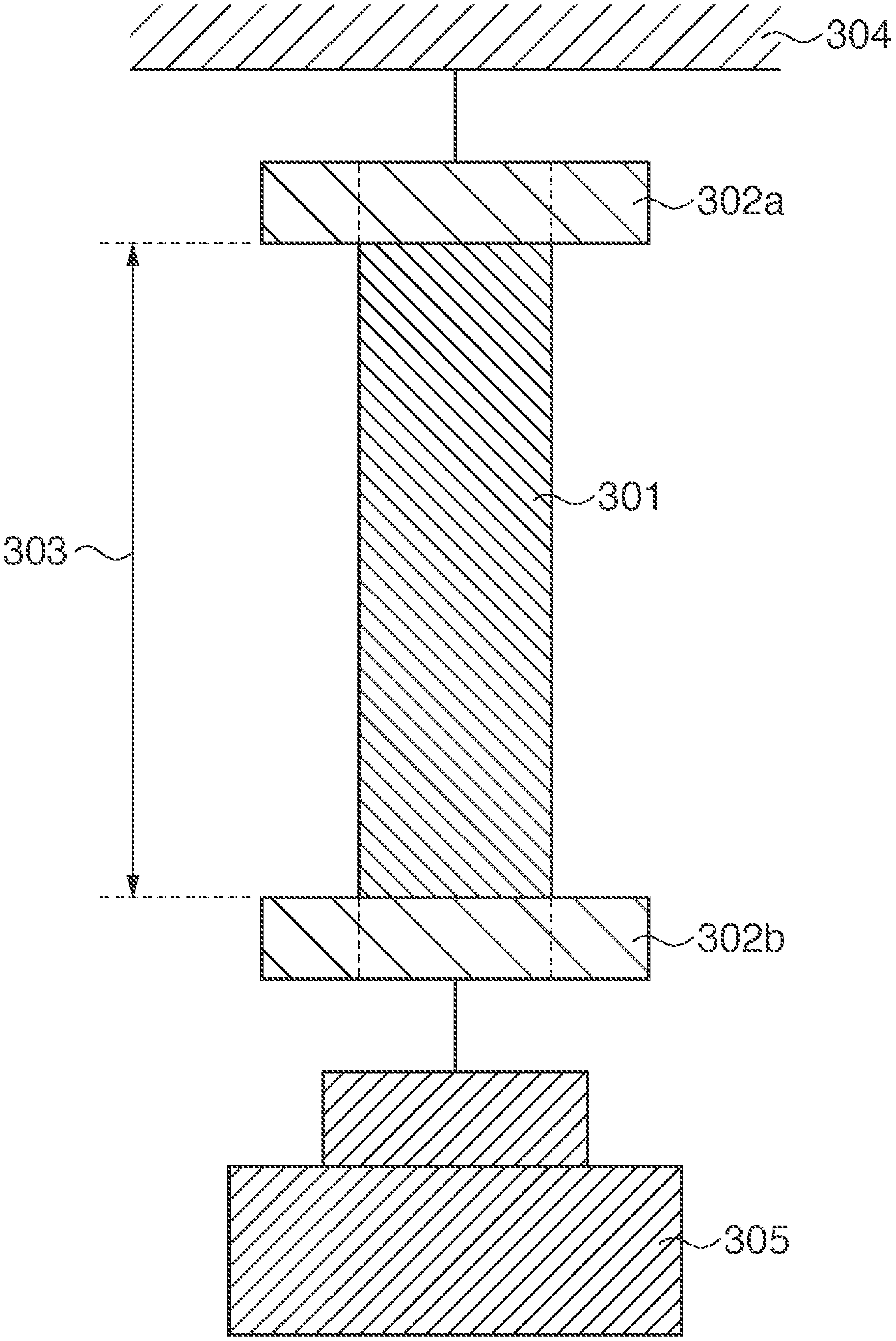


FIG. 4

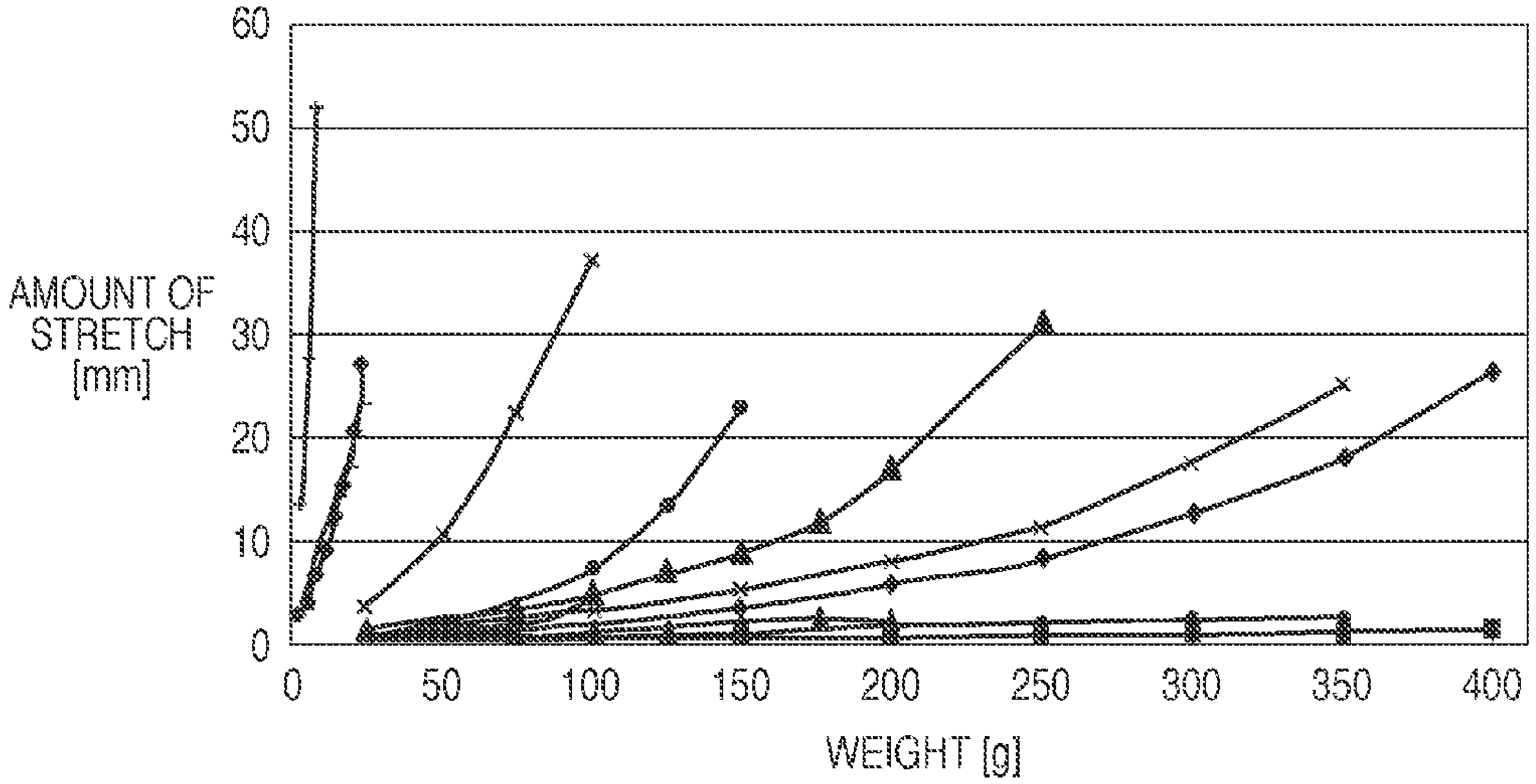

AMOUNT OF STRETCH [mm]
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
400
WEIGHT [g]

FIG. 5

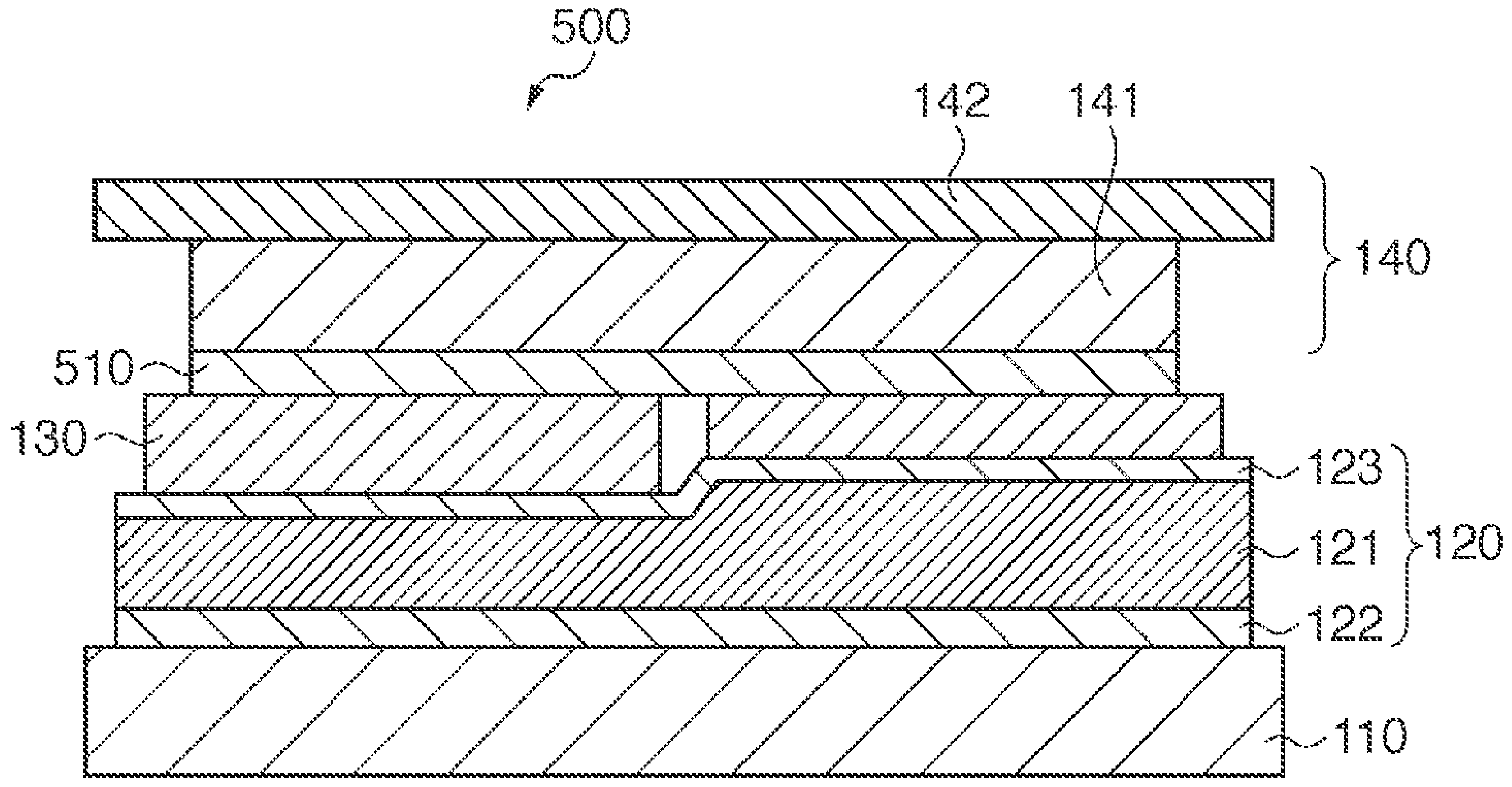
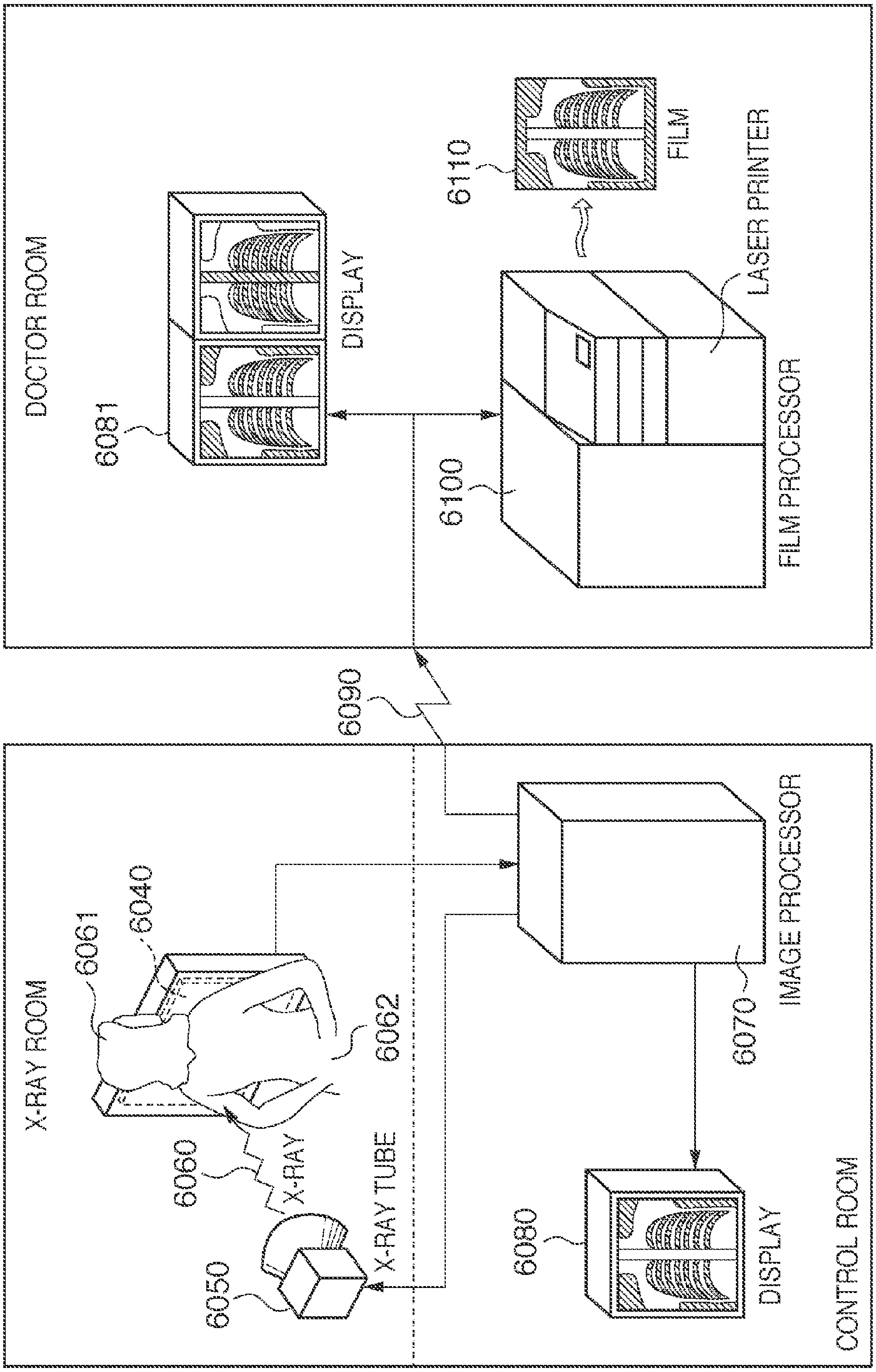

500
142
141
140
510
130
123
121
120
122
110

FIG. 6


X-RAY ROOM
6061
6040
6062
6060
X-RAY
6050
X-RAY TUBE
6070
IMAGE PROCESSOR
6080
DISPLAY
CONTROL ROOM
6090
DOCTOR ROOM
6081
DISPLAY
6100
FILM PROCESSOR
LASER PRINTER
6110
FILM

RADIATION DETECTION APPARATUS AND RADIATION IMAGING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a radiation detection apparatus and a radiation imaging system. In this specification, radiation includes electromagnetic waves such as X-rays and γ-rays.

2. Description of the Related Art

Recently implemented semiconductor substrates of radiation detection apparatuses have large areas. The larger the area of the semiconductor substrate, the lower the yield per unit of substrate, and the greater the amount of loss per unit of substrate. For this reason, a plurality of semiconductor substrates is arrayed to achieve increases in the areas of the semiconductor substrates. When arraying a plurality of semiconductor substrates, it is preferable that they have a uniform height. According to Japanese Patent Laid-Open No. 2008-224429, the height of the upper surface of a semiconductor substrate is adjusted by bonding the lower surface of the semiconductor substrate to a base through a sheet-like porous damper member.

SUMMARY OF THE INVENTION

When arraying a plurality of semiconductor substrates, it is necessary to set proper intervals between the semiconductor substrates as well as making their upper surfaces have a uniform height. The technique disclosed in Japanese Patent Laid-Open No. 2008-224429 can equalize the surface heights of semiconductor substrates by making a damper member contract in a direction perpendicular to the upper surface of each semiconductor substrate. At the same time, however, because the damper member stretches in a direction parallel to each semiconductor substrate, the intervals between the semiconductor substrates increase. One aspect of the present invention therefore provides a technique of suppressing shifts in the intervals between a plurality of semiconductor substrates in a radiation detection apparatus in which the semiconductor substrates are arranged.

An aspect of the present invention provides a radiation detection apparatus comprising: a plurality of semiconductor substrates each having a first surface on which a photoelectric conversion portion for detecting light is formed and a second surface opposite to the first surface; a scintillator layer, placed over the first surfaces of the plurality of semiconductor substrates, for converting radiation into light; and an elastic member, placed between a base and the second surfaces of the plurality of semiconductor substrates, for supporting the second surfaces of the plurality of semiconductor substrates such that the first surfaces of the plurality of semiconductor substrates are flush with each other, wherein, in measurement of the elastic member as a single body, an amount of stretch of a cubic specimen in a direction parallel to the first surface when being compressed in a direction perpendicular to the first surface is smaller than an amount of stretch of the specimen in the direction perpendicular to the first surface when being compressed in the direction parallel to the first surface.

Further features of the present invention will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the description, serve to explain the principles of the invention.

FIG. **1** is a schematic sectional view of an example of a radiation detection apparatus according to one embodiment;

FIG. **2** is a view for explaining the anisotropy of a base material;

FIG. **3** is a view for explaining a method of measuring the amount of stretch of a base material;

FIG. **4** is a graph for explaining the relationship between the amount of stretch of a base material and the weight of a weight member;

FIG. **5** is a schematic sectional view of another example of the radiation detection apparatus according to a second embodiment; and

FIG. **6** is a view for explaining a radiation imaging system according to another embodiment.

DESCRIPTION OF THE EMBODIMENTS

The embodiments of the present invention will be described below with reference to the accompanying drawings.

An example of a radiation detection apparatus **100** according to one embodiment will be described with reference to FIG. **1**. FIG. **1** is a schematic sectional view of the radiation detection apparatus **100**. The radiation detection apparatus **100** may include a base **110**, an elastic member **120**, a plurality of semiconductor substrates **130**, and a scintillator panel **140**. The scintillator panel **140** may include a scintillator layer **141** and a support substrate **142**. The scintillator layer **141** converts radiation which has entered the radiation detection apparatus **100** into light. The scintillator layer **141** may be formed by, for example, vapor-depositing CsI on the support substrate **142**.

The semiconductor substrate **130** has a surface (first surface) **132** on which a photoelectric conversion portion **134** is formed, and detects light converted by the scintillator layer **141**. The scintillator panel **140** is placed over the surface (first surface) **132** on which the photoelectric conversion portion **134** is formed. The radiation detection apparatus **100** may include a plurality of semiconductor substrates **130**. FIG. **1** shows the two semiconductor substrates **130** as an example. However, the number of substrates that may be used is not limited to this. The surfaces of the semiconductor substrates **130** which are located on the scintillator panel **140** side are fixed to be flush with each other. The surfaces (second surfaces) **136** of the semiconductor substrates **130** which are located on the side opposite to the scintillator panel **140** are supported by the elastic member **120** fixed to the base **110**.

The elastic member **120** may include a base material **121** and adhesion layers **122** and **123** sandwiching the base material **121**. The semiconductor substrates **130** are bonded to the base material **121** through the adhesion layer **123**. The base **110** is bonded to the base material **121** through the adhesion layer **122**. That is, the elastic member **120** also serves as an adhesion member. The base material **121** may be covered by an adhesive material instead of being sandwiched between the adhesion layers **122** and **123**.

For the sake of the following description, a direction parallel to the surface of the semiconductor substrate **130** which is located on the scintillator panel **140** side will be simply referred to as a parallel direction **151**, and a direction perpendicular to the surface will be simply referred to as a perpendicular direction **152**. The base material **121** has anisotropy with respect to the amount of stretch. Assume that a cubic specimen is extracted from the base material **121** and is singly measured. The amount of stretch of this specimen in the parallel direction **151** upon compression in the perpendicular direction **152** is smaller than that in the perpendicular direction **152** upon compression in the parallel direction **151**. This will be described in detail with reference to FIG. **2**. The upper portion of FIG. **2** shows a state in which a semiconductor substrate **130***a* and a semiconductor substrate **130***b* are aligned on the elastic member **120**. Assume that in this case, the thickness (the length in the perpendicular direction **152**) of the semiconductor substrate **130***a* is larger than the thickness of the semiconductor substrate **130***b*. The interval between the semiconductor substrate **130***a* and the semiconductor substrate **130***b* is represented by a, and the length of the elastic member **120** in the perpendicular direction **152** is represented by b. In this state, the semiconductor substrate **130***a* is pressed into the elastic member **120** such that the surfaces of the semiconductor substrates **130***a* and **130***b* which are located on the scintillator panel **140** side are flush with each other. As a result, as indicated by the lower portion of FIG. **2**, the interval between the semiconductor substrate **130***a* and the semiconductor substrate **130***b* becomes an interval c, and the length of a portion of the elastic member **120** which is located under the semiconductor substrate **130***a* in the perpendicular direction **152** becomes a length d. In this case, since the base material **121** has anisotropy with respect to expansion/contraction, the amount of stretch (c−a) of the elastic member **120** in the parallel direction **151** is smaller than that of an elastic member having isotropy. The amount of stretch (c−a) of the elastic member **120** in the parallel direction **151** may be smaller than the allowable margin of the intervals between the semiconductor substrates **130**. In addition, the length b of the elastic member **120** in the perpendicular direction **152** may be larger than variations in the thicknesses of the semiconductor substrates **130**.

The base material **121** may be formed by, for example, a polyolefin-based resin, polyester, unwoven fabric, chemical fiber, wire mesh, or the like. It is possible to use a polystyrene-based resin, of polyolefin-based resins, which has relatively high flexibility. This wire may be, for example, a metal wire or resin wire. It is possible to select, as a material for the adhesion layers **122** and **123**, for example, at least one of the following materials: an acrylic material, epoxy-based material, rubber-based material, polyester-based material, polyamide-based material, vinyl alkylether-based material, and silicone-based adhesive material. In addition, it is possible to select, as a material for the adhesion layer **123**, a combination of materials having heat-releasable adhesive layers including heat-expandable microspheres. This makes it possible to release the base material **121** from a plurality of semiconductor substrates **130** to replace, for example, some semiconductor substrates **130**.

A method of measuring the amount of stretch of the base material **121** in the parallel direction **151** will be described next with reference to FIG. **3**. The amount of stretch of the base material **121** in the parallel direction **151** when being compressed in the perpendicular direction **152** has a correlation with the amount of stretch of the base material **121** in the parallel direction **151** when being stretched in the parallel direction **151**. In the following operation, therefore, the amount of stretch of a specimen when it is stretched is measured. The amount of stretch of the base material **121** in the perpendicular direction **152** can also be measured by the same measurement method. First of all, a specimen **301** is extracted from the base material **121** such that it has a length of 120 mm in the parallel direction **151** and a length of 10 mm in the perpendicular direction **152**. Two PET (polyethylene terephthalate) sheets **302***a* and **302***b* each having a width of 20 mm and a length of 10 mm are prepared, and the weight of the PET sheet **302***b* is measured. The portions of the specimen **301**, each having a length of 10 mm and extending from a corresponding end portion by 10 mm, are tucked into the PET sheets **302***a* and **302***b*, respectively. In this case, the center lines of the specimen **301** and PET sheets **302***a* and **302***b* coincide with each other. Tucking the specimen **301** into the PET sheets **302***a* and **302***b* in this manner makes the elastic portion of the specimen **301** have a length **303** of 100 mm. The PET sheet **302***a* is suspended from a support member **304**. In this state, the length **303** is measured. The value obtained by subtracting 100 mm from the length **303** in the suspended state is equivalent to the amount of stretch of the specimen **301** due to the weight of the PET sheet **302***b*. Weight members **305** of various weights are then suspended from the PET sheet **302***b*, and the amounts of stretch of the specimen **301** are measured. With regard to the suspended weight member **305**, the value obtained by subtracting 100 mm from the length **303** is equivalent to the amount of stretch of the specimen **301**, which corresponds to the sum of the weights of the PET sheet **302***b* and weight member **305**. FIG. **4** is a graph showing the relationship between the sums of the weights of specimens **301** made of various materials and the weights of weight members and the amounts of stretch. For example, letting d be the amount of stretch and x be the weight of the weight member **305**, it is possible to select the base material **121** which satisfy $d \leq 0.563\exp(0.00253x)$ and use it for the radiation detection apparatus **100**.

A modification of the above embodiment will be described below with reference to FIG. **5**. The same reference numerals as in FIG. **1** denote the same constituent elements in FIG. **5**, and a description of them will be omitted. A semiconductor detection apparatus **500** shown in FIG. **5** includes an adhesion layer **510** between the scintillator layer **141** and the semiconductor substrates **130**. The scintillator layer **141** is bonded to the semiconductor substrates **130** through the adhesion layer **510**.

As described above, according to the above embodiment, since the elastic member which supports the plurality of semiconductor substrates **130** has anisotropy with respect to expansion/contraction, it is possible to suppress shifts in the intervals between the respective semiconductor substrates.

The example of the above embodiment will be described below.

First Example

Assume that the first example uses, as a material for a base material **121**, a PET material of the above materials which has relatively high hardness, with the thickness being 10 μm or more and 500 μm or less. The first example also selects, as a material for an adhesion layer **123**, a material from materials having heat-releasable adhesive layers including heat-expandable microspheres. In addition, an adhesion layer **122** has a thickness of 10 μm or more and 100 μm or less. The first example uses a material having relatively high hardness for the base material **121** to suppress the expansion/contraction of the adhesion layer **123** in a parallel direction **151** when releasing semiconductor substrates **130** from the base material **121** by heating the adhesion layer **123**. This prevents the semiconductor substrates **130** from colliding with each other.

Second Example

The second example associated with the modification described above with reference to FIG. **5** will be described below. Since semiconductor substrates **130** may have different thicknesses, bubbles may enter between an adhesion layer

510 and the semiconductor substrates **130** when a scintillator panel **140** is bonded to the semiconductor substrates **130**. Even if vacuum/pressure defoaming processing is performed to remove the bubbles, some bubbles may remain. The presence of residual bubbles will degrade the quality of an output image because light which is converted by the scintillator panel **140** and propagates toward the semiconductor substrates **130** changes due to reflection and refraction.

The second example therefore uses, as a material for a base material **121**, a PET material of the above materials which has relatively high hardness, and sets the thickness of the base material **121** to 10 μm or more and 50 μm or less. Although it is possible to use the above material as a material for an adhesion layer **123**, it is possible to select a material from materials having heat-releasable adhesive layers including heat-expandable microspheres, in particular, to facilitate replacement of the semiconductor substrate **130**. This makes it possible for an adhesion layer **122** and the adhesion layer **123** to efficiently absorb shifts of the semiconductor substrates **130** in a perpendicular direction **152**. This prevents shifts of the semiconductor substrates **130** in a parallel direction **151** and residual bubbles between the semiconductor substrates **130** and the adhesion layer **510** after vacuum/pressure defoaming processing.

Third Example

The third example associated with the modification described with reference to FIG. **5** will be described below. The third example uses, as an adhesion layer **122**, an elastic adhesive layer formed by an elastic adhesive material. In this case, the elastic adhesive layer may have anisotropy with respect to expansion/contraction like a base material **121**. For example, a sheet-like polystyrene material is used as a material for the base material of the elastic adhesive layer, and a damper sheet using an acrylic adhesive material is especially effective as each of adhesive layers on the two surfaces of the base material. As a base material for the elastic adhesive layer, a polyolefin-based resin, polyester, or the like can be used. It is also possible to use a non-elastic material as the adhesion layer **122** instead of the above material, and to place an elastic adhesive layer (not shown) between the adhesion layer **122** and a base **110**. This prevents shifts of semiconductor substrates **130** in a parallel direction **151** and residual bubbles between the semiconductor substrates **130** and an adhesion layer **510** after vacuum/pressure defoaming processing, even if PET is used as a material for the base material **121** and its thickness is 50 μm or more and 500 μm or less. The third example uses, as a material for an adhesion layer **123**, the same material as that in each of the first and second examples, and can select a material from materials having heat-releasable adhesive layers including heat-expandable microspheres, in particular.

Other Embodiments

FIG. **6** is a view showing an example of the application of an X-ray imaging apparatus according to the present invention to an X-ray diagnostic system (radiation imaging system). An X-ray **6060** generated by an X-ray tube **6050** (radiation source) is transmitted through a chest region **6062** of a patient **6061** and strikes a photoelectric conversion apparatus **6040** (a photoelectric conversion apparatus having a scintillator mounted on its upper portion forms the above radiation detection apparatus) having a scintillator mounted on its upper portion. The incident X-ray contains information inside the body of the patient **6061**. The scintillator emits light when X-rays strike it. This light is photoelectrically converted to obtain electrical information. This information is converted into a digital signal. An image processor **6070** serving as a signal processing unit performs image processing for the digital signal to allow observation of the resultant image on a display **6080** serving as a display unit in a control room. Note that the radiation imaging system includes at least an imaging apparatus and a signal processing unit which processes signals from the imaging apparatus.

In addition, a transmission processing unit on a network **6090** such as a telephone line or the Internet can transfer this information to a remote place to allow the information to be displayed on a display **6081** serving as a display unit or be stored in a recording unit such as an optical disk in a doctor's room or the like in another place. This allows a doctor to perform diagnosis in a remote location. In addition, a film processor **6100** serving as a recording unit can record the information on a film **6110** serving as a recording medium.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2010-143919, filed Jun. 24, 2010, and No. 2010-255311, filed Nov. 15, 2010, which are hereby incorporated by reference herein in their entirety.

What is claimed is:

1. A radiation detection apparatus comprising:

a plurality of semiconductor substrates each having a first surface on which a photoelectric conversion portion for detecting light is formed and a second surface opposite to said first surface;

a scintillator layer, placed over said first surfaces of said plurality of semiconductor substrates, for converting radiation into light; and

an elastic member, placed between a base and said second surfaces of the plurality of semiconductor substrates, for supporting said second surfaces of said plurality of semiconductor substrates such that said first surfaces of said plurality of semiconductor substrates are aligned flush with each other,

wherein, in measurement of said elastic member as a single body, an amount of stretch of a cubic specimen in a direction parallel to said first surface when being compressed in a direction perpendicular to said first surface is smaller than an amount of stretch of the specimen in the direction perpendicular to said first surface when being compressed in the direction parallel to said first surface.

2. The apparatus according to claim **1**, wherein said elastic member includes a base material formed by at least one of unwoven fabric, chemical fiber, and wire mesh.

3. The apparatus according to claim **2**, wherein said elastic member further includes a heat-releasable adhesive layer for bonding said plurality of semiconductor substrates to said base material.

4. The apparatus according to claim **2**, wherein said elastic member further includes an elastic adhesive layer for bonding said base material to the base.

5. A radiation imaging system comprising:

a radiation detection apparatus according to claim **1**; and

a signal processing unit configured to process a signal obtained from said radiation detection apparatus.

6. The apparatus according to claim **1**, wherein said plurality of semiconductor substrates have different thickness from each other.

7. The apparatus according to claim **1**, wherein said second surfaces of said plurality of semiconductor substrates have different heights from the base from each other.

8. A radiation detection apparatus comprising:

a plurality of semiconductor substrates each having a first surface on which a photoelectric conversion portion for detecting light is formed and a second surface opposite to said first surface;

a scintillator layer, placed over said first surfaces of said plurality of semiconductor substrates, for converting radiation into light; and

an elastic member, placed over a base, for supporting said second surfaces of said plurality of semiconductor substrates such that said first surfaces of said plurality of semiconductor substrates are aligned flush with each other,

wherein an amount of stretch of said elastic member in a direction parallel to said first surface is smaller than an amount of stretch of said elastic member in a direction perpendicular to said first surface.

9. A radiation detection apparatus comprising:

a plurality of semiconductor substrates each having a first surface on which a photoelectric conversion portion for detecting light is formed and a second surface opposite to said first surface;

a scintillator layer, placed over said first surfaces of said plurality of semiconductor substrates, for converting radiation into light; and

an elastic member, placed over a base, for supporting said second surfaces of said plurality of semiconductor substrates such that said first surfaces of said plurality of semiconductor substrates are aligned flush with each other,

wherein a stretch rate of said elastic member in a direction parallel to said first surface is smaller than a stretch rate of said elastic member in a direction perpendicular to said first surface.

* * * * *